US009129878B2

(12) **United States Patent**
Su et al.

(10) **Patent No.: US 9,129,878 B2**
(45) **Date of Patent: Sep. 8, 2015**

(54) **MECHANISMS FOR FORMING BACKSIDE ILLUMINATED IMAGE SENSOR DEVICE STRUCTURE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 59 days.

(21) Appl. No.: **14/029,402**

(22) Filed: **Sep. 17, 2013**

(65) **Prior Publication Data**

US 2015/0076638 A1 Mar. 19, 2015

(51) **Int. Cl.**

H01L 31/0232 (2014.01)
H01L 27/146 (2006.01)

(52) **U.S. Cl.**

CPC ***H01L 27/1464*** (2013.01); ***H01L 27/14625*** (2013.01); ***H01L 27/14636*** (2013.01); ***H01L 27/14643*** (2013.01); ***H01L 27/14689*** (2013.01)

(58) **Field of Classification Search**

CPC H01L 27/14643; H01L 27/1464; H01L 27/14636; H01L 2924/00; H01L 27/14685
USPC 257/432, 437, E27.13, E31.119, 257/E31.127
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,400,003	B2 *	7/2008	Lee et al.	257/291
8,610,229	B2 *	12/2013	Hsu et al.	257/432
2012/0038015	A1 *	2/2012	Huang et al.	257/437

* cited by examiner

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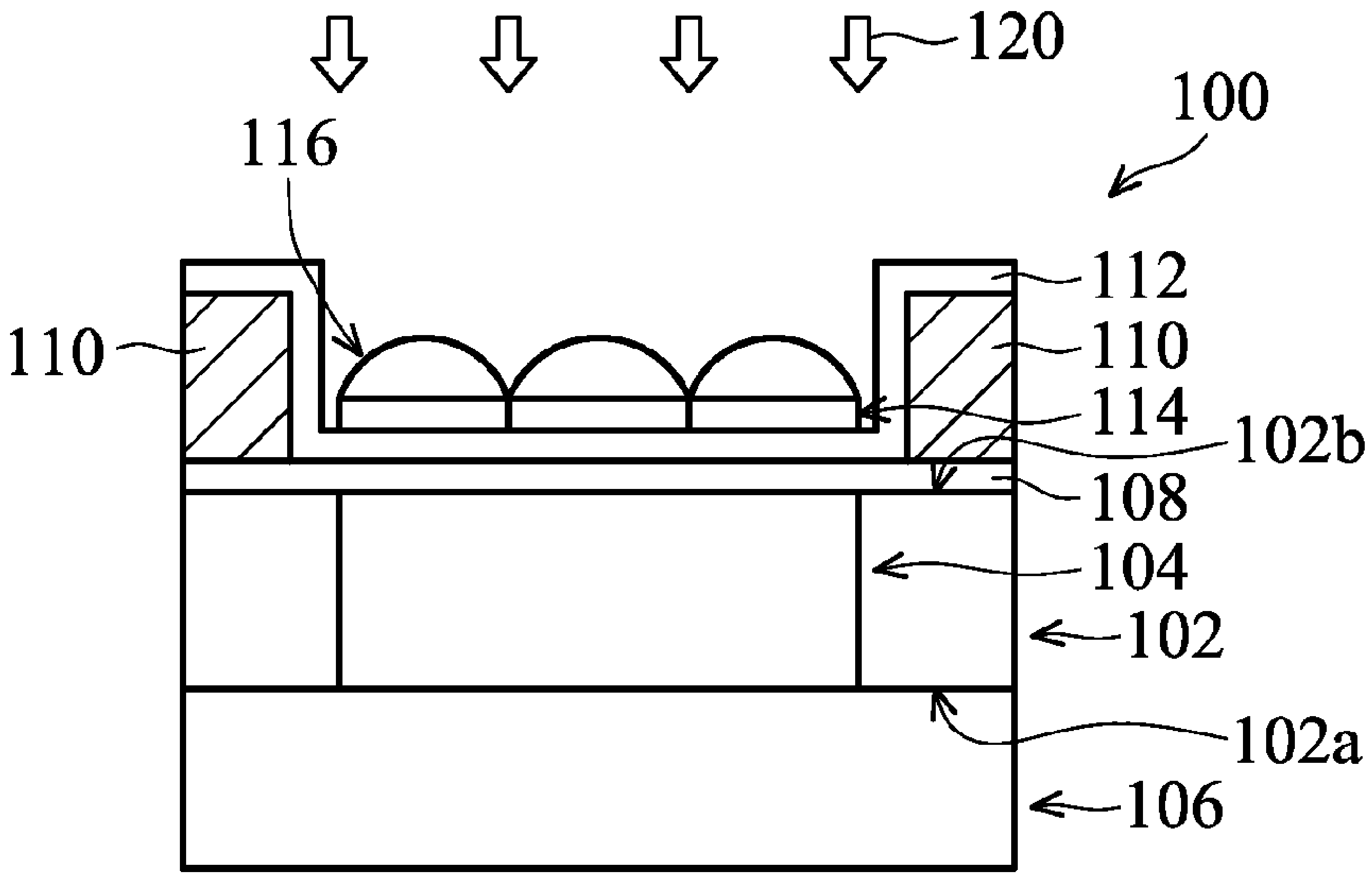
(57) **ABSTRACT**

Embodiments of mechanisms of a backside illuminated image sensor device structure are provided. The backside illuminated image sensor device structure includes a substrate having a frontside and a backside and a pixel array formed in the frontside of the substrate. The backside illuminated image sensor device structure further includes an antireflective layer formed over the backside of the substrate, and the antireflective layer is made of silicon carbide nitride.

16 Claims, 4 Drawing Sheets



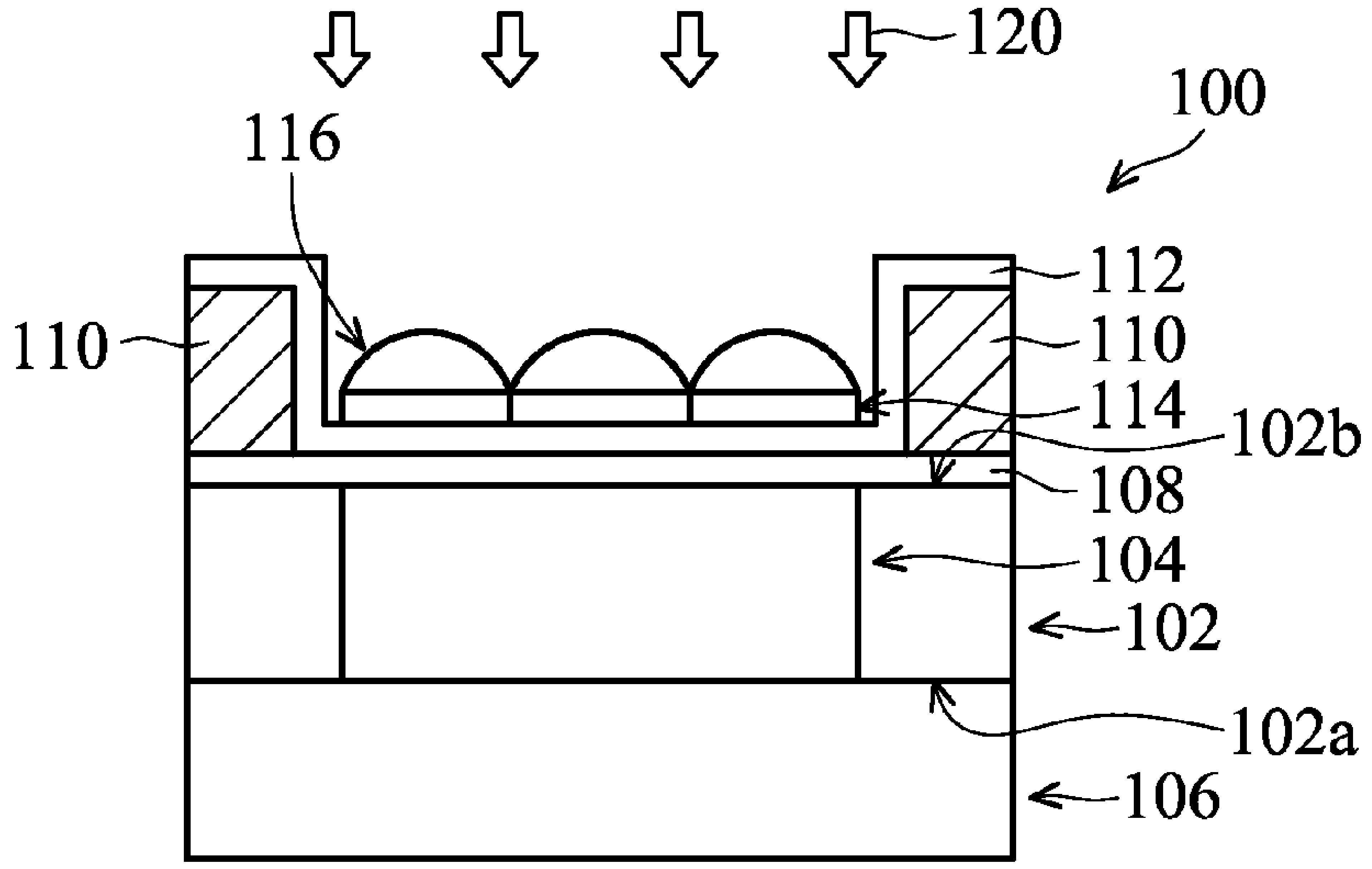


FIG. 1

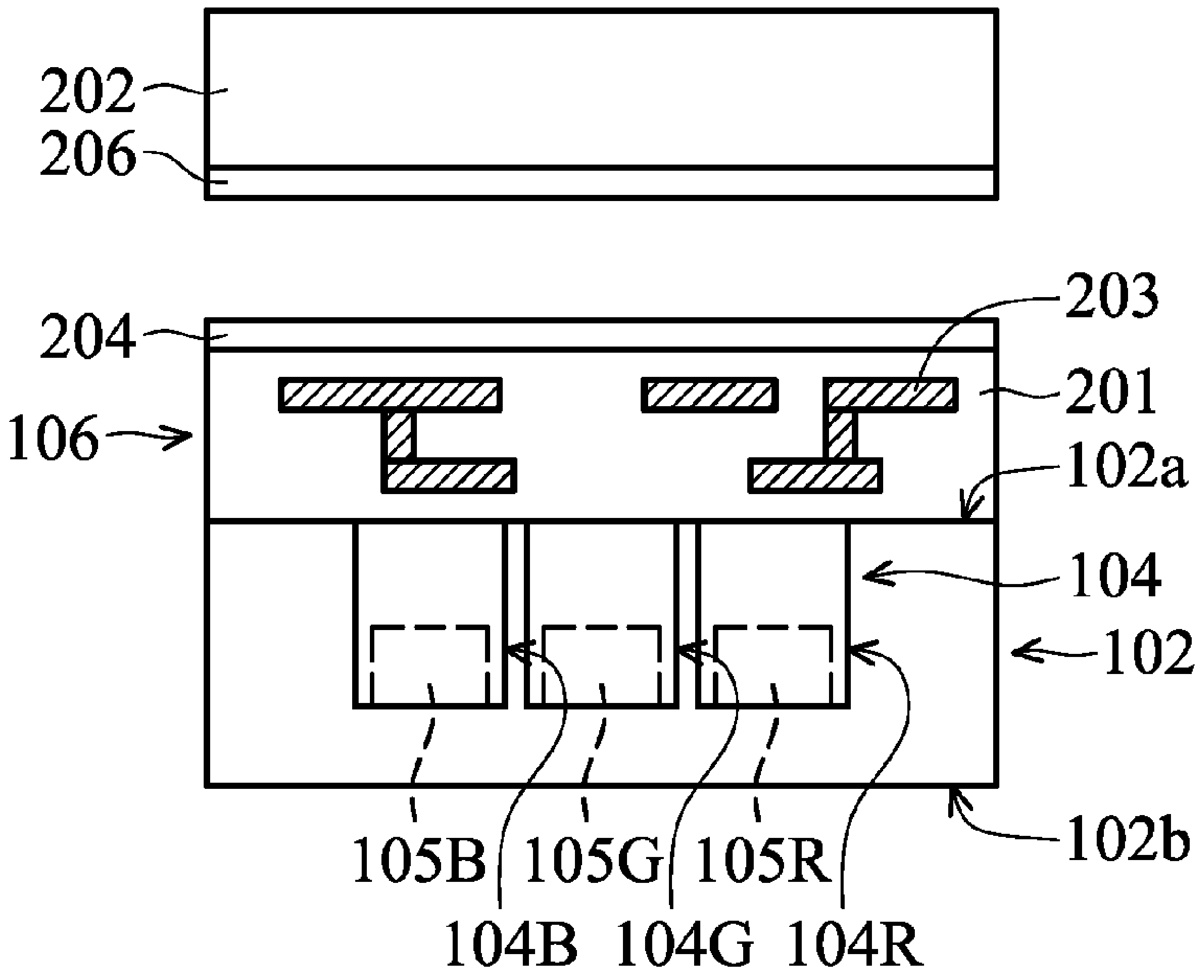

202
206
204
203
201
106
102a
104
102
105B
105G
105R
102b
104B
104G
104R

FIG. 2A

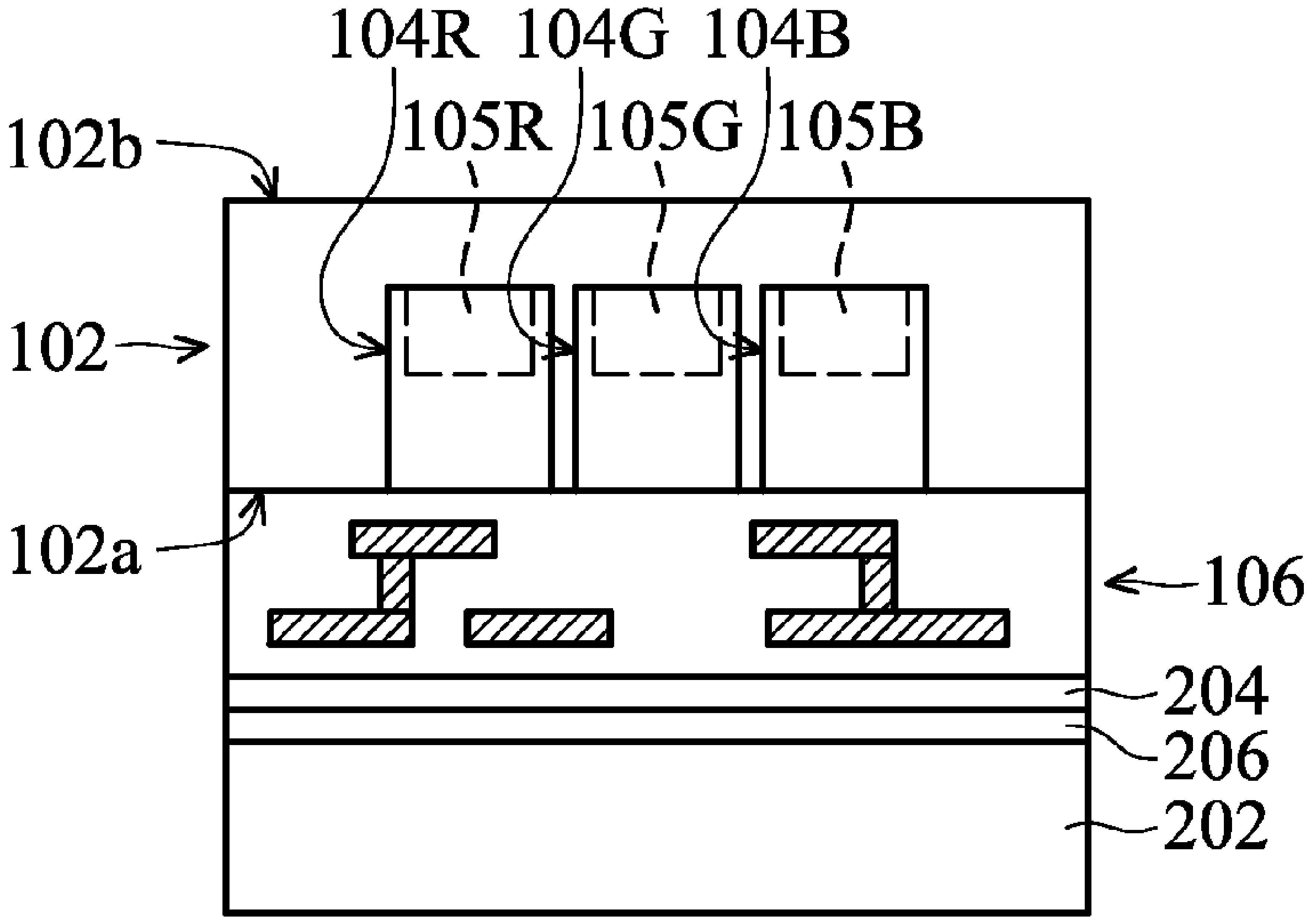

104R
104G
104B
105R
105G
105B
102b
102
102a
106
204
206
202

FIG. 2B

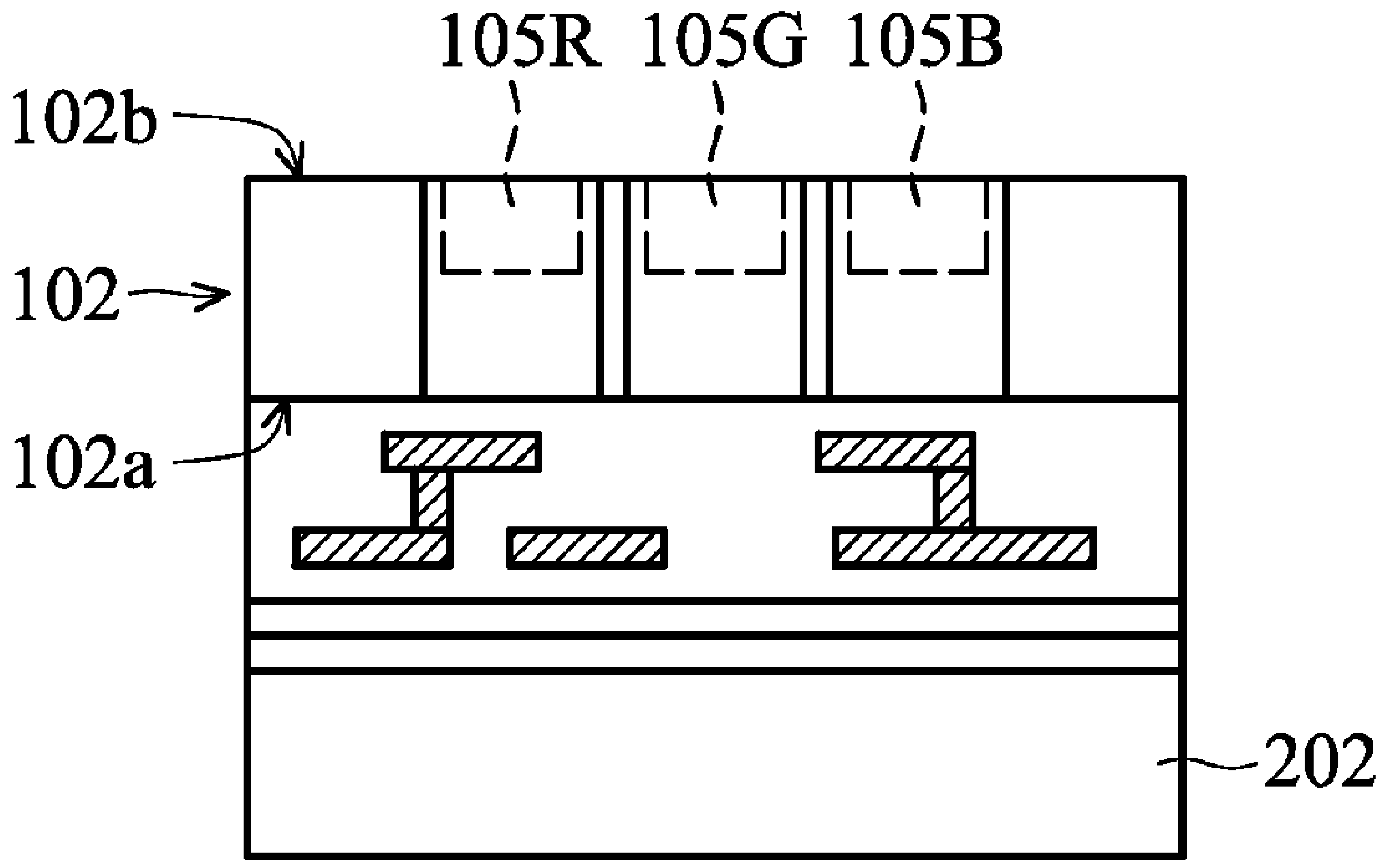

105R
105G
105B
102b
102
102a
202

FIG. 2C

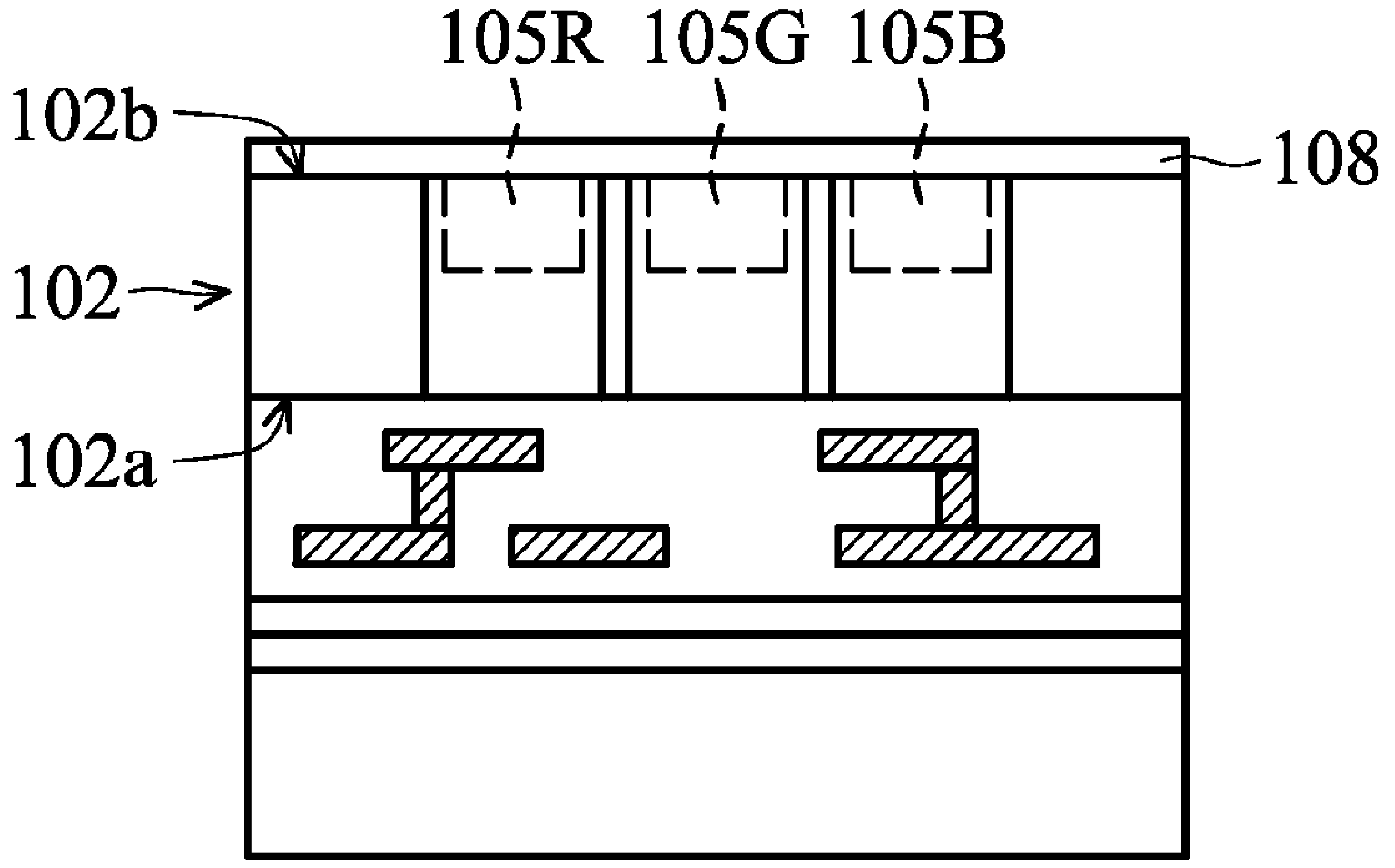

105R
105G
105B
102b
108
102
102a

FIG. 2D

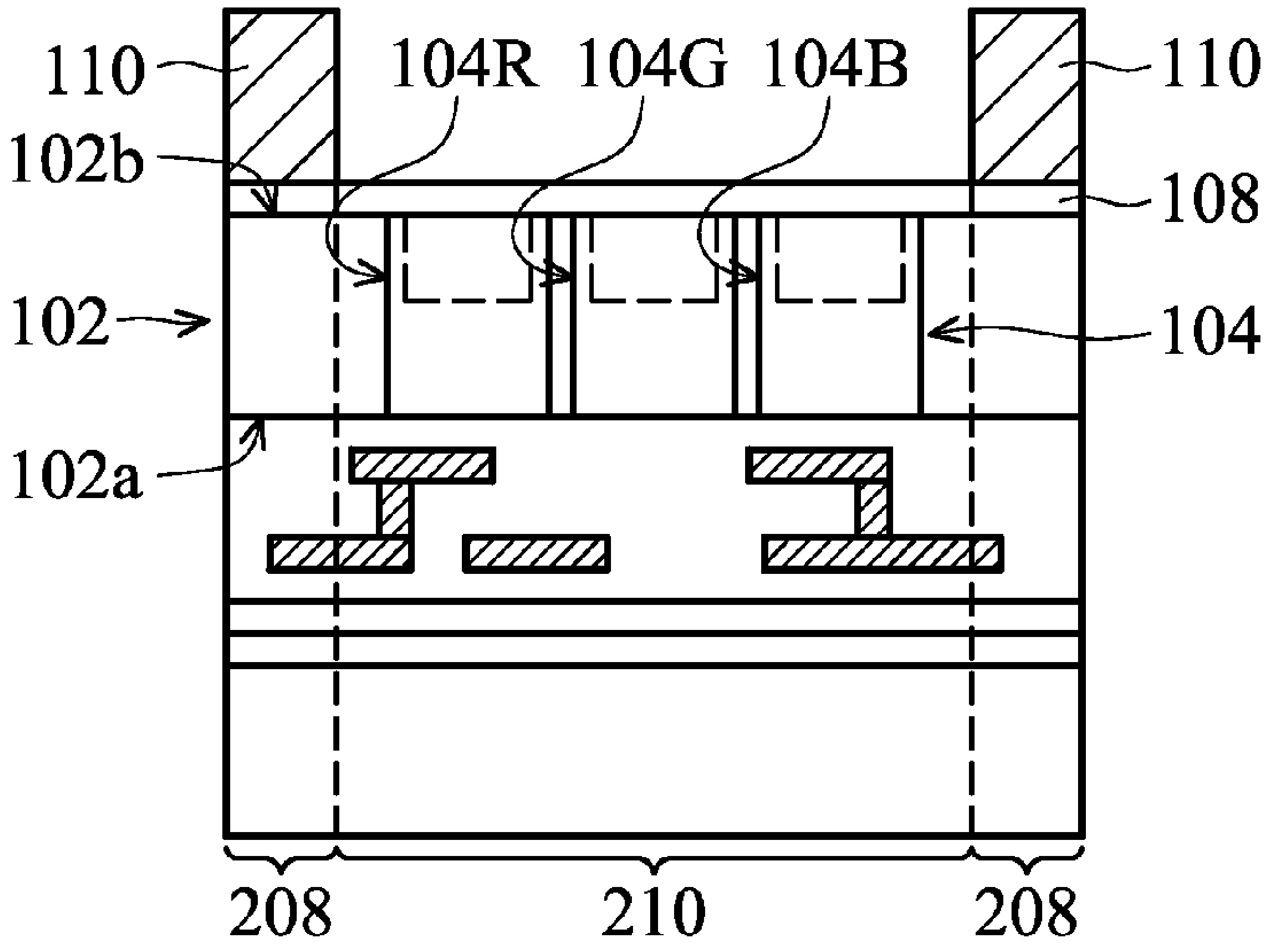

110
104R
104G
104B
110
102b
108
102
104
102a
208
210
208

FIG. 2E

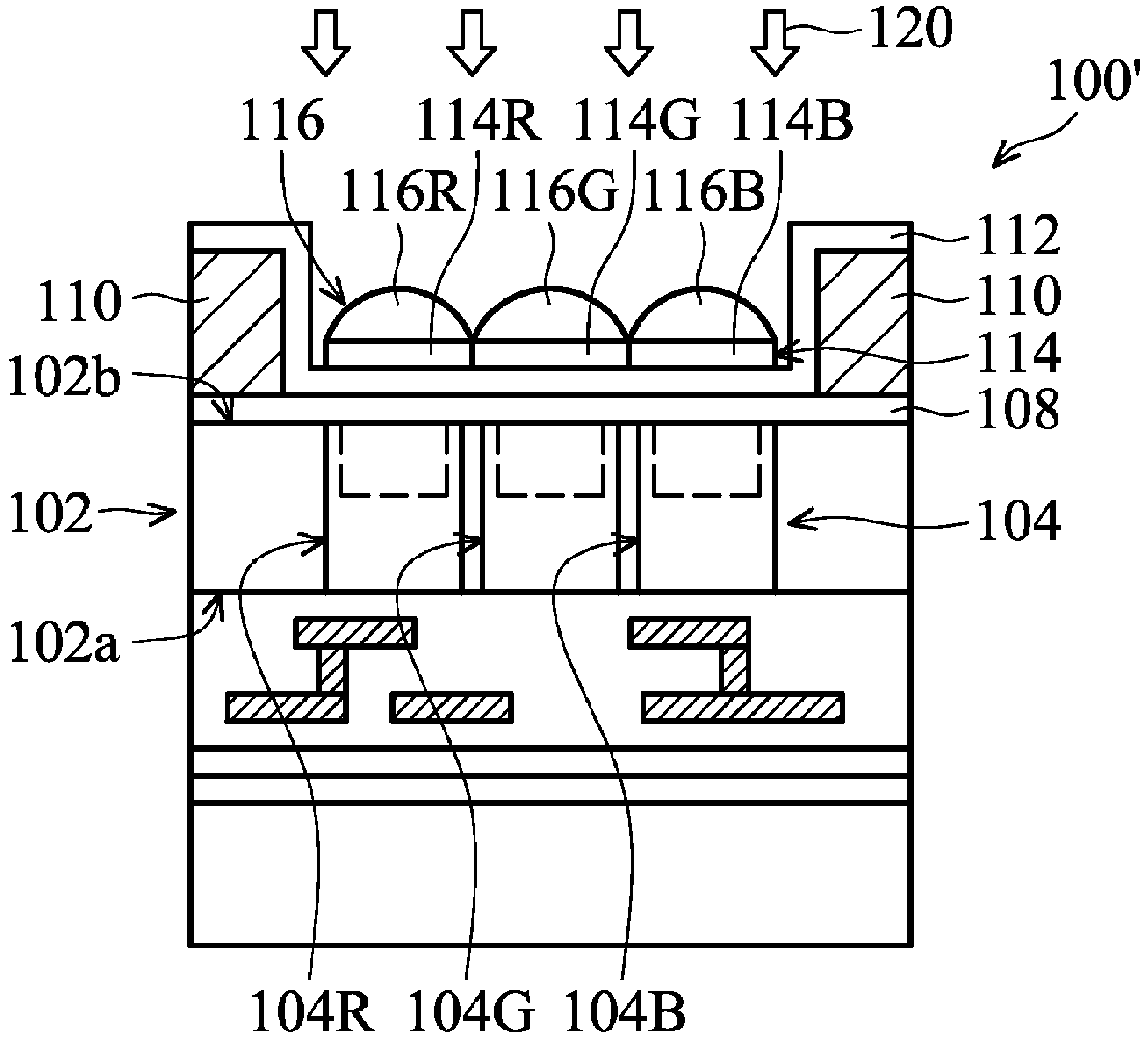

120
100'
116
114R
114G
114B
116R
116G
116B
112
110
110
114
102b
108
102
104
102a
104R
104G
104B

FIG. 2F

MECHANISMS FOR FORMING BACKSIDE ILLUMINATED IMAGE SENSOR DEVICE STRUCTURE

BACKGROUND

Integrated circuit (IC) technologies are constantly being improved. Such improvements frequently involve scaling down device geometries to achieve lower fabrication costs, higher device integration density, higher speeds, and better performance.

One of the IC devices is an image sensor device. An image sensor device includes a pixel grid for detecting light and recording intensity (brightness) of the detected light. The pixel grid responds to the light by accumulating charges. The charges can be used (for example, by other circuitry) to provide color in some suitable applications, such as a digital camera.

Common types of pixel grids include a charge-coupled device (CCD) image sensor or complimentary metal-oxide-semiconductor (CMOS) image sensor device. One type of image sensor devices is a backside illuminated (BSI) image sensor device. BSI image sensor devices are used for sensing a volume of light projected towards a backside surface of a substrate. BSI image sensor devices provide a high fill factor and reduced destructive interference, as compared to front-side illuminated (FSI) image sensor devices. In general, BSI technology provides higher sensitivity, lower cross-talk, and comparable quantum efficiency as compared to FSI image sensor devices.

However, although existing BSI image sensor devices and methods of fabricating these BSI image sensor devices have been generally adequate for their intended purposes, as device scaling-down continues, they have not been entirely satisfactory in all respects.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present disclosure, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates a cross section representation of a backside illuminated (BSI) image sensor device structure in accordance with some embodiments.

FIGS. **2**A to **2**F illustrate cross-section representations of various stages of forming a BSI image sensor device structure in accordance with some embodiments.

DETAILED DESCRIPTION

The making and using of the embodiments of the disclosure are discussed in detail below. It should be appreciated, however, that the embodiments can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative, and do not limit the scope of the disclosure.

It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of the disclosure. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. Moreover, the performance of a first process before a second process in the description that follows may include embodiments in which the second process is performed immediately after the first process, and may also include embodiments in which additional processes may be performed between the first and second processes. Various features may be arbitrarily drawn in different scales for the sake of simplicity and clarity. Furthermore, the formation of a first feature over or on a second feature in the description that follows include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact.

Some variations of the embodiments are described. Throughout the various views and illustrative embodiments, like reference numbers are used to designate like elements.

Mechanisms for forming an integrated circuit (IC) device structure are provided in accordance with some embodiments of the disclosure. In some embodiments, the IC device is a backside illuminated (BSI) image sensor device. FIG. **1** illustrates a cross section representation of a backside illuminated (BSI) image sensor device structure **100** in accordance with some embodiments.

Backside illuminated (BSI) image sensor device structure **100** includes a substrate **102** having a pixel array **104**, an interconnect structure **106** formed over a frontside **102***a* of substrate **102**, and an antireflective layer **108** formed over a backside **102***b* of substrate **102**, as shown in FIG. **1** in accordance with some embodiments. In addition, BSI image sensor device structure **100** further includes a radiation shielding layer **110** formed over portions of antireflective layer **108** and a passivation layer **112** formed over the backside of substrate **102** to cover radiation shielding layer **110** and antireflective layer **108**. A color filter layer **114** and microlens layer **116** are formed over passivation layer **112** in a pixel area of substrate **102**. As shown in FIG. **1**, an incident radiation **120** passes through microlens layer **116**, color filter layer **114**, and antireflective layer **108** sequentially and reaches pixel array **104**.

In some embodiments, passivation layer **112** is made of dielectric material such as silicon nitride (Si_3N_4). In some embodiments, antireflective layer **108** is also made of silicon nitride. However, when antireflective layer **108** is made of Si_3N_4, a refractive index of antireflective layer **108** is similar to a refractive index of passivation layer **112**. Therefore, a transmittance of BSI image sensor device structure **100** decreases, resulting from total reflection of incident radiation **120**.

In some embodiments, antireflective layer **108** is made of dielectric material such as silicon carbide (SiC). When antireflective layer **108** is made of SiC, the refractive index of antireflective layer **108** is higher than the refractive index of passivation layer **112**. Therefore, the transmittance of BSI image sensor device structure **100** may be improved. However, antireflective layer **108** made of SiC tends to trap charges in optical block areas of BSI image sensor device structure **100** (e.g. areas below radiation shielding layer **110**), and the dark current in substrate **102** increases.

FIGS. **2**A to **2**F illustrate cross-section representations of various stages of forming a BSI image sensor device structure **100'** in accordance with some embodiments. However, it should be noted that BSI image sensor device structure **100'** illustrated in FIGS. **2**A to **2**F have been simplified for the sake of clarity so that concepts of the present disclosure can be better understood. Therefore, in some other embodiments, additional features are added in BSI image sensor device structure **100'**, and some of the elements are replaced or eliminated. For example, BSI image sensor device structure **100'** is an integrated circuit (IC) chip, system-on-chip (SoC), or a portion thereof, which includes various passive and active microelectronic devices, such as resistors, capacitors, inductors, diodes, metal-oxide-semiconductor field effect transistors (MOSFET), complementary metal-oxide-semiconductor (CMOS) transistors, high-voltage transistors, high-frequency transistors, or other applicable components. In addition, it should be noted that different embodiments may have different advantages than those described herein, and no particular advantage is necessarily required of any embodiment.

In some embodiments, substrate **102** is a semiconductor substrate including silicon. Alternatively or additionally, substrate **102** may include another elementary semiconductor, such as germanium and/or diamond; a compound semiconductor including silicon carbide, gallium arsenic, gallium phosphide, indium phosphide, indium arsenide, and/or indium antimonide; an alloy semiconductor including SiGe, GaAsP, AlInAs, AlGaAs, GaInAs, GaInP, and/or GaInAsP. Substrate **102** may be a p-type or an n-type substrate depending on the design requirements of BSI image sensor device structure **100**. Substrate **102** may also include isolation features (not shown), such as shallow trench isolation (STI) and/or local oxidation of silicon (LOCOS) features, to separate the pixels (discussed below) and/or other devices formed on substrate **102**. In some embodiments, substrate **102** is a device wafer.

As shown in FIG. **2**A, pixel array **104** is formed in frontside **102***a* of substrate **102** in accordance with some embodiments. Pixel array **104** includes pixels **104**R, **104**G, and **104**B corresponding to specific wavelengths. For example, pixels **104**R, **104**G, and **104**B respectively correspond to a range of wavelengths of red light, green light, and blue light. Therefore, each of pixels **104**R, **104**G, and **104**B may detect the intensity (brightness) of a respective range of wavelengths. The term “pixel” refers to a unit cell containing features (for example, circuitry including a photodetector and various semiconductor devices) for converting electromagnetic radiation into electrical signals. Pixels **104**R, **104**G, and **104**B may include various features and circuitry allowing them to detect the intensity of incident radiation **120**.

In some embodiments, pixels **104**R, **104**G, and **104**B are photodetectors, such as photodiodes, that include light-sensing regions **105**R, **105**G, and **105**B, respectively. Light-sensing regions **105**R, **105**G, and **105**B may be doped regions having n-type and/or p-type dopants formed in substrate **102**. Light-sensing regions **105**R, **105**G, and **105**B may be formed by an ion implantation process, diffusion process, or other applicable etching process.

Interconnect structure **106** is formed over frontside **102***a* of substrate **102**, as shown in FIG. **2**A in accordance with some embodiments. Interconnect structure **106** includes a dielectric layer **201** and conductive features **203** formed in dielectric layer **201**. In some embodiments, dielectric layer **201** includes interlayer (or inter-level) dielectric (ILD) layers or inter-metal dielectric (IMD) layers. In some embodiments, dielectric layer **201** includes multilayers made of multiple dielectric materials, such as silicon oxide, silicon nitride, silicon oxynitride, tetraethoxysilane (TEOS), phosphosilicate glass (PSG), borophosphosilicate glass (BPSG), low-k dielectric material, other applicable dielectric materials. Examples of low-k dielectric materials include, but are not limited to, fluorinated silica glass (FSG), carbon doped silicon oxide, amorphous fluorinated carbon, parylene, bis-benzocyclobutenes (BCB), or polyimide. Dielectric layer **201** may be formed by a chemical vapor deposition (CVD), physical vapor deposition, (PVD), atomic layer deposition (ALD), spin-on coating, or other applicable process.

Conductive features **203** may be configured to connect various features or structures of BSI image sensor device

100'. For example, conductive features **203** are used to interconnect the various devices formed on substrate **102**. Conductive features **203** may be vertical interconnects, such as vias and/or contacts, and/or horizontal interconnects, such as conductive lines. In some embodiments, conductive features **203** are made of conductive materials, such as aluminum, aluminum alloy, copper, copper alloy, titanium, titanium nitride, tungsten, polysilion, or metal silicide.

An adhesive layer **204** is formed over interconnect structure **106** over frontside **102***a* of substrate **102**. In some embodiments, adhesive layer **204** is an oxide layer. Adhesive layer **204** may be formed by chemical vapor deposition (CVD). As shown in FIG. **2**A, an adhesive **206** is also formed on a carrier substrate **202**. In some embodiments, adhesive layer **206** is an oxide layer. Adhesive layer **206** may be formed by CVD. In some embodiments, adhesive layer **204** and adhesive layer **206** are made of the same material. In some embodiments, carrier substrate **202** is a carrier wafer. In some embodiments, carrier substrate **202** is a glass substrate.

Substrate **102** is bonded to carrier substrate **202** by bonding adhesive layer **204** to adhesive layer **206**, as shown in FIG. **2**B in accordance with some embodiments. As shown in FIG. **2**B, adhesive layer **204** formed on interconnect structure **106** over frontside **102***a* of substrate **102** is bonded to adhesive layer **206** formed on carrier substrate **202**. Therefore, substrate **102** is bonded to carrier substrate **202** through its frontside **102***a*.

After adhesive layer **204** is bonded to adhesive layer **206**, backside **102***b* of substrate **102** is polished to thin down substrate **102**, as shown in FIG. **2**C in accordance with some embodiments. As shown in FIG. **2**C, substrate **102** is thinned down from its backside **102***b* to expose light-sensing regions **105**R, **105**G, and **105**B. In some embodiments, substrate **102** is polished by a chemical mechanical polishing (CMP) process.

Next, antireflective layer **108** is formed over backside **102***b* of substrate **102** to cover exposed light-sensing regions **105**R, **105**G, and **105**B, as shown in FIG. **2**D in accordance with some embodiments. In some embodiments, antireflective layer **108** is made of silicon carbide nitride. In some embodiments, antireflective layer **108** is made of SiC_xN_y, and a ratio of y to x is in a range from about 0.01 to about 0.5. When the ratio of y to x is too large, RI would be lower and might cause record intensity (quantum efficiency) loss. When the ratio of y to x is too small, total electrical charge would be too high and might cause CMOS noise increasing. In some embodiments, the thickness of antireflective layer **108** is in a range from about 100 Å to about 600 Å.

In some embodiments, the refraction index of antireflective layer **108** is in a range from about 2.3 to about 2.6. In some embodiments, the refraction index of antireflective layer **108** is smaller than the refraction index of pixel array **104**. In some embodiments, the extinction coefficient (k) of antireflective layer **108** is substantially zero for radiation (light) having wavelengths in a range from about 425 nm to about 650 nm. Antireflective layer **108** made of silicon carbide nitride has a relatively high refraction index (e.g. compared to the refraction index of the antireflective layer made of Si_3N_4 being about 1.92), and therefore the transmittance of the resulting BSI image sensor device structure **100'** will be improved.

In some embodiments, a total charge (Q_{total}) of antireflective layer **108** is in a range from about 1.5E+11 q/cm^2 to about 6.5E+11 q/cm^2. In some embodiments, a flatband voltage of antireflective layer **108** is in a range from about −2.7 volt to about −12 volt. Since antireflective layer **108** has a relatively larger flatband voltage (e.g. compared to the flatband voltage of silicon carbide being about **−11.99**), the dark current of the resulting BSI image-sensor device structure **100'** will be reduced.

In some embodiments, formation of antireflective layer **108** made of SiC_xN_y can be presented by the following formula:

$$(CH_3)_3SiH+NH_3 \rightarrow SiC_xN_y+\text{byproduct}$$

In some embodiments, the byproduct is the formula may be hydrogen, or C_xH_x. As described previously, the ratio of y to x is in a range from about 0.01 to about 0.5. In some embodiments, antireflective layer **108** is formed by a chemical vapor deposition (CVD) process, such as a plasma enhanced CVD (PECVD) process. In some embodiments, the PECVD process includes using a gas mixture containing helium (He), ammonia (NH_3), and tetramethylsilane (TMS). In some embodiments, a flow rate of He is in a range from about 1000 sccm to about 5000 sccm. In some embodiments, a flow rate of NH_3 is in a range from about 5 sccm to about 300 sccm. In some embodiments, a flow rate of TMS is in a range from about 50 sccm to about 300 sccm. The flow rates of each gas may be used to control the composition and thickness of antireflective layer **108**. In some embodiments, the ratio of the flow rate of NH_3 to the flow rate of TMS is in a range from about 0.2 to about 1.

In some embodiments, during the PECVD process, a chamber pressure is in a range from about 1 Torr to about 30 Torr. In some embodiments, a chamber temperature is in a range from about 300° C. to about 500° C. In some embodiments, a power is in a range from about 100 W to about 500 W.

After antireflective layer **108** is formed, radiation shielding layer **110** is formed over antireflective layer **108**, as shown in FIG. **2**E in accordance with some embodiments. Radiation shielding layer **110** is used to block radiation (light) from passing through, and therefore areas below radiation shielding layer **110** are called optical block areas **208**. On the other hand, an area with pixel array **104** formed inside is called a pixel area **210**. In some embodiments, pixel area **210** is surrounded by optical block areas **208**.

In some embodiments, radiation shielding layer **110** includes one or more metal layers made of metal containing materials such as titanium, titanium nitride, tantalum, tantalum nitride, aluminum, tungsten, copper, or copper alloy. In some embodiments, radiation shielding layer **110** is formed by using a physical vapor deposition (PVD) process or a chemical vapor deposition (CVD) process. In some embodiments, a thickness of radiation shielding layer **110** is in a range from about 100 angstroms to about 1000 angstroms.

Next, passivation layer **112** is formed conformally over backside **102***b* of substrate **102**, as shown in FIG. **2**F in accordance with some embodiments. Passivation layer **112** covers radiation shielding layer **110** in optical block areas **208** and pixel array **104** in pixel area **210**. In some embodiments, passivation layer **112** directly contacts radiation shielding layer **110** in pixel area **210** in accordance with some embodiments. Therefore, incident radiation **120** passes through passivation layer **112** and antireflective layer **108** sequentially to reach pixel array **104**.

In some embodiments, passivation layer **112** is made of silicon nitride or silicon oxynitride. In some embodiments, a refractive index of passivation layer **112** is lower than 2.2, such as in a range from about 1.8 to about 2.2. In some embodiments, a difference between the refractive index of antireflective layer **108** and the refractive index of passivation layer **112** is in a range from about 0.1 to about 1.0. When the difference between the refractive index of antireflective layer **108** and the refractive index of passivation layer **112** is too small, total reflection may occurs during the operation of BSI image sensor device **100'**. In some embodiments, a thickness of passivation layer **112** is in a range from about 250 angstroms to about 4000 angstroms.

After passivation layer **112** is formed, color filter layer **114** is formed over passivation layer **112**, and microlens layer **116** is disposed over color filter layer **114**, as shown in FIG. **2**F in accordance with some embodiments. Color filter layer **114** may include more than one color filter. For example, color filter layer **114** includes color filters **114**R, **114**G, and **114**B. Incident radiation **120** may be filtered by color filter **114**R, and the filtered incident radiation **120**, such as being transferred into a red light, may reach pixel **104**R. Similarly, incident radiation **120** filtered by color filter **114**G, such as being transferred into a green light, may reach pixel **104**G, and incident radiation **120** filtered by color filter **114**B, such as being transferred in to a blue light, may reach pixel **104**B. In some embodiments, each of the color filters **114**R, **114**G, and **114**B is aligned with its respective, corresponding pixels **104**R, **104**G, and **104**B.

In some embodiments, color filters **114**R, **114**G, and **114**B are made of a dye-based (or pigment-based) polymer for filtering out a specific frequency band. In some embodiments, color filters **114**R, **114**G, and **114**B are made of a resin or other organic-based material having color pigments.

In some embodiments, microlens layer **116** disposed on color filter layer **114** includes microlens **116**R, **116**G, and **116**B. As shown in FIG. **2**F, each of microlens **116**R, **116**G, and **116**B is aligned with one of the corresponding color filters **114**R, **114**G, and **114**B, and therefore is aligned with one of the corresponding pixels **104**R, **104**G, and **104**B. However, it should be noted that microlens **116**R, **116**G, and **116**B may be arranged in various positions in various applications. In addition, microlens **116**R, **116**G, and **116**B may have a variety of shapes and sizes, depending on the refraction index of materials of microlenses **116**R, **116**G, and **116**B and/or the distance between microlenses **116**R, **116**G, and **116**B and light-sensing regions **105**R, **105**G, and **105**B.

In operation, BSI image sensor device structure **100'** is designed to receive incident radiation **120** traveling towards backside **102***b* of substrate **102**, as shown in FIG. **2**F in accordance with some embodiments. First, microlens layer **116** directs incident radiation **120** to color filter layer **114**. Next, incident radiation **120** passes from color filter layer **114** to pixel array **104** through passivation layer **112** and antireflective layer **108**. In some embodiments, incident radiation **120** is a visible light, infrared (IR), ultraviolet (UV), X-ray, or microwave.

As described above, refractive index of antireflective layer **108** made of silicon carbide nitride is higher than refractive index of passivation layer **112**, and refractive index of pixel array **104** is higher that refractive index of antireflective layer **108**. That is, incident radiation **120** passes through layers having various but increasing refractive index. Therefore, amounts of total reflection of incident radiation **120** (e.g. incident light) are greatly decreased. In addition, the decrease of total reflection leads to an increase of transmittance of BSI image sensor device structure **100'**. Accordingly, intensity of incident radiation **120** reaching substrate **102** increases, and quantum efficiency of BSI image sensor device structure **100'** is improved.

In addition, amounts of charges trapped by antireflective layer **108** made of silicon carbide nitride decreases (e.g. compared to antireflective layer made of silicon carbide), and therefore the dark current of BSI image sensor device structure **100'** in optical block area **208** of substrate **101** is also decreased.

Embodiments of mechanisms for a BSI image sensor device structure are provided. The BSI image sensor device structure includes an antireflective layer formed over a backside of a device substrate and a passivation layer formed over the antireflective layer. The antireflective layer is made of silicon carbide nitride. A refractive index of the antireflective layer is larger than a refractive index of the passivation layer. Therefore, transmittance of the BSI image sensor device structure increases, and quantum efficiency of the BSI image sensor device structure is improved. In addition, amounts of charges trapped by the antireflective layer decreases, and therefore dark current of the BSI image sensor device structure also decreases.

In some embodiments, a backside illuminated image sensor device structure is provided. The backside illuminated image sensor device structure includes a substrate having a frontside and a backside and a pixel array formed in the frontside of the substrate. The backside illuminated image sensor device structure further includes an antireflective layer formed over the backside of the substrate, and the antireflective layer is made of silicon carbide nitride

In some embodiments, a backside illuminated image sensor device structure is provided. The backside illuminated image sensor device structure includes a substrate having a frontside and a backside and a pixel array formed in the frontside of the substrate. The backside illuminated image sensor device structure further includes an antireflective layer formed over the backside of the substrate, wherein the antireflective layer is made of SiC_xN_y, and wherein a ratio of y to x is in a range from about 0.01 to about 0.5.

In some embodiments, a method for forming a backside illuminated image sensor device structure is provided. The method includes providing a device substrate having a pixel array formed in a frontside of the device substrate and forming an interconnect structure over the frontside of the device substrate. The method further includes bonding a carrier substrate to the interconnect structure over the frontside of the device substrate and polishing a backside of the device substrate to expose the pixel array from the backside of the device substrate. The method further includes forming an antireflective layer over the backside of the device substrate to cover the pixel array, and the antireflective layer is made of silicon carbide nitride.

Although embodiments of the present disclosure and their advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the disclosure as defined by the appended claims. For example, it will be readily understood by those skilled in the art that many of the features, functions, processes, and materials described herein may be varied while remaining within the scope of the present disclosure. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present disclosure, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present disclosure. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

What is claimed is:

1. A backside illuminated image sensor device structure comprising:

a substrate having a frontside and a backside;

a pixel array formed in the frontside of the substrate;

an antireflective layer formed over the backside of the substrate, wherein the antireflective layer is made of silicon carbide nitride;

a radiation shielding layer formed over the antireflective layer over the backside of the substrate;

a passivation layer formed over the backside of the substrate to cover the radiation shielding layer and the pixel array; and

a color filter layer formed over the passivation layer, wherein the color filter layer is aligned with the pixel array.

2. The backside illuminated image sensor device structure as claimed in claim **1**, wherein the silicon carbide nitride has the following formula:

$$SiC_xN_y,$$

wherein a ratio of y to x is in a range from about 0.01 to about 0.5.

3. The backside illuminated image sensor device structure as claimed in claim **1**, wherein a refraction index of the antireflective layer is in a range from about 2.3 to about 2.6.

4. The backside illuminated image sensor device structure as claimed in claim **1**, wherein a thickness of the antireflective layer is in a range from about 100 Å to about 600 Å.

5. The backside illuminated image sensor device structure as claimed in claim **1**, wherein a refraction index of the antireflective layer is larger than a refraction index of the passivation layer.

6. The backside illuminated image sensor device structure as claimed in claim **5**, wherein a difference between the refraction index of the antireflective layer and the refraction index of the passivation layer is in a range from about 0.1 to about 1.0.

7. The backside illuminated image sensor device structure as claimed in claim **1**, further comprising:

a microlens layer disposed over the color filter layer.

8. The backside illuminated image sensor device structure as claimed in claim **1**, wherein refraction index of the antireflective layer is smaller than a refraction index of the pixel array.

9. The backside illuminated image sensor device structure as claimed in claim **1**, wherein a refractive index of the passivation layer is in a range from about 1.8 to about 2.2.

10. A backside illuminated image sensor device structure, comprising:

a substrate having a frontside and a backside;

a pixel array formed in the frontside of the substrate;

an antireflective layer formed over the backside of the substrate, wherein the antireflective layer is made of SiC_xN_y, and wherein a ratio of y to x is in a range from about 0.01 to about 0.5;

a radiation shielding layer formed over the antireflective layer over the backside of the substrate;

a passivation layer formed over the backside of the substrate to cover the radiation shielding layer and the pixel array; and

a color filter layer formed over the passivation layer, wherein the color filter layer is aligned with the pixel array.

11. The backside illuminated image sensor device structure as claimed in claim **10**, wherein a refraction index of the antireflective layer is in a range from about 2.3 to about 2.6.

12. The backside illuminated image sensor device structure as claimed in claim **10**, wherein a refraction index of the antireflective layer is larger than a refraction index of the passivation layer.

13. The backside illuminated image sensor device structure as claimed in claim **12**, wherein a difference between the refraction index of the antireflective layer and the refraction index of the passivation layer is in a range from about 0.1 to about 1.0.

14. The backside illuminated image sensor device structure as claimed in claim **10**, further comprising:

a microlens layer disposed over the color filter layer.

15. The backside illuminated image sensor device structure as claimed in claim **10**, wherein a thickness of the antireflective layer is in a range from about 100 Å to about 600 Å.

16. The backside illuminated image sensor device structure as claimed in claim **10**, wherein a refraction index of the antireflective layer is smaller than a refraction index of the pixel array.

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